Notes on Successful Spawning and Recruitment of a Stocked Population of the Endangered Australian Freshwater Fish, Trout Cod, *Maccullochella macquariensis* (Cuvier) (Percichthyidae)

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Conservation efforts for endangered fish species often include captive breeding programs that aim to re-establish viable populations in the wild. This study presents the first confirmed record of natural recruitment, to sub-adult, in a population of the endangered Australian freshwater fish, trout cod (*Maccullochella macquariensis*) derived from the stocking of captive-bred fingerlings. This represents a significant step in the conservation efforts for this species.

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INTRODUCTION

Captive breeding programs that release progeny into the wild are common strategies used in the conservation of endangered fish species (Philippart 1995) The ultimate measure of success of such programs is the establishment of viable populations in the wild. Initial steps for this to be achieved include the development of breeding techniques, the placement of captive-bred animals where they can survive and grow, the initiation of natural spawning, and the recruitment and subsequent breeding in first generation individuals. Although not the only method for saving species, such programs are important conservation tools for fisheries managers, to be used in conjunction with habitat maintenance and protective legislation (Gooley 1992a). In Australia, artificial breeding techniques have been developed to assist conservation efforts for several threatened freshwater fish species, including the endangered trout cod, *Maccullochella macquariensis* Cuvier (Pisces: Percichthyidae) (Ingram and Rimmer 1992).

BACKGROUND

The trout cod is an endemic Australian fish considered threatened on an international level (Ingram and Douglas 1995). The species was once widespread throughout the southern Murray Darling River system of southeast Australia, but suffered a severe decline in range and abundance (Cadwallader and Gooley 1984). The species is restricted to only two isolated breeding populations (Ingram et al. 1990).

National trout cod conservation efforts focus on protecting the existing populations with legislation and attempting to increase the number of self-sustaining populations through release of small fish produced from captive breeding programs (Douglas et al. 1994). Techniques to induce the species to breed in hatcheries were developed in the mid 1980s (Ingram and Rimmer 1992) and continued refinement of techniques has provided sufficient numbers of fingerlings, on a regular basis, to stock into selected waters. Since 1988 over 20 waters have been stocked with hatchery produced trout cod (Douglas et al. 1994).

While there is evidence of liberated trout cod surviving to at least breeding age at many of the release sites (Douglas et al. 1994), there is no evidence of successful recruitment to adult from any of these populations. Preliminary evidence of spawning has been noted (Harris and Rowland 1996) from 1994 when a single larva (13.2 mm TL) and a single fingerling (92 mm TL) were sampled from two separate stocking sites in New South Wales. The larva was identified as a trout cod from diagnosis of myomere and pre-caudal vertebral counts (Brown and Neira 1998), and the wild origin of the fingerling was identified amongst fish of hatchery origin by the lack of enhanced otolith strontium concentration, which is used to mark hatchery-produced larvae in New South Wales (Brown and Harris 1995). Subsequent surveys of these two sites have found no further evidence of wild-bred juveniles or older year-classes.

Loombah Weir (146°13'10" E, 36°43'18" S) was one of the original trout cod stocking sites in Victoria. Trout cod were not present in the weir prior to the stocking. Between 1988 and 1991, 8000 trout cod fingerlings, approximately 10-12 weeks old, were released into the only feeder stream above the impounded waters of the weir. Loombah Weir is a domestic water storage and was chosen because the catchment was relatively undisturbed and the area had limited public access. Non-destructive surveys between 1992 and 1995 monitored survival and growth of the stocked fish and recorded movement of fish downstream into the backed up waters of the weir.

A monitoring survey in June 1998 using boat-mounted electrofishing produced a single adult (704 mm total length, > 5 kg) and two smaller trout cod (228 mm total length, 156 g and 199 mm total length, 91 g respectively) from the weir. The large fish was undoubtedly a survivor from one of the original stockings and was released. However, the size of the smaller fish implied they were likely to be younger than any of the previously liberated fish. Therefore both fish were sacrificed to estimate their ages from otolith sections.

AGE DETERMINATION

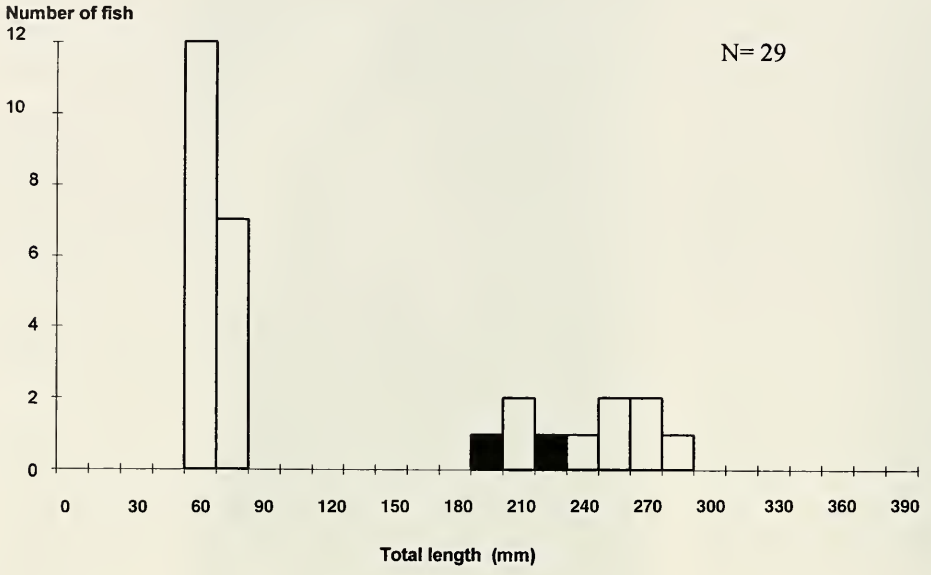
Age determination of the sampled fish was made by otolith reading and corroborated by length frequency analysis.

Although the counting of annual growth increments in thin-sections of saggital otolith has not been validated for trout cod, it has been validated for the closely related species *Maccullochella peelii peelii* (Anderson et al. 1992a; Gooley 1992b) and *Macquaria ambigua* (Anderson et al. 1992b) and is likely to provide a valid method for estimating trout cod age. Thin sections of trout cod otoliths have previously been examined from over 70 juvenile and adult fish collected ad hoc from a variety of both natural and stocked populations. They show clear increments, which closely resemble those seen on the sibling species *M. peelii peelii* (S Morison, Central Ageing Facility, Queenscliff pers. comm.). Increment formation in *M. peelii peelii* occurs in September-November (Anderson et al. 1992a; Gooley 1992b). Examination of thin sectioned saggital otoliths from the two trout cod sampled from Loombah in 1998 revealed two opaque zones with a wide marginal increment (Fig. 1). This suggests that the fish were in their third year.

The length-frequency distribution of trout cod, derived from a previous post-stocking survey in Loombah Weir in 1990 (Fig. 2) shows a size class between 210 and 300 mm total length. These fish were the oldest possible trout cod in the weir at the time and were in their third year (as trout cod had not been stocked into the site prior to 1988). The

Figure 1. Transverse section through a sagittal otolith of a trout cod sampled from Loombah weir, June 1998. Fish TL 199 mm and weight 99 g. Two clear increments (•) are visible on both dorsal and ventral sides and a third increment is about to be formed on the edge. The fish is estimated to be 3 years of age. Scale bar = 1 mm

Figure 2. Comparison of length structure in samples of trout cod from a previous Loombah survey (1990) (clear bars) and the recently captured juvenile trout cod in 1998 (filled bars).



lengths of the recently sampled trout cod (228 mm and 199 mm total length) are consistent with these 3-year-old fish, which provides additional confidence to the otolith based age estimates for these individuals.

This age estimate suggests the birth year for the recently sampled trout cod as 1995, and from the known biology of trout cod, the date would be from October to November (Ingram and Rimmer 1992, Douglas et al. 1994)

Since the stocking of trout cod in Loombah Weir ceased in 1991, the youngest possible age of stocked fish in 1998, in the impoundment, would have been seven years. Therefore, based on length and otoliths, the age estimates of the two trout cod sampled in 1998 indicate that these fish were younger than any stocked fish. Because no trout cod could gain access to the weir from other areas, the fish must be derived from a natural spawning of the previously stocked fish.

This constitutes the first evidence of natural recruitment from a stocked population of hatchery-bred trout cod in Victoria and the first evidence of recruitment to three years of age from the natural spawning of any captive-bred trout cod population in Australia.

DISCUSSION

The time needed for the trout cod stocking program to produce viable breeding populations is unknown. However, because trout cod, like other large percichthyids, are likely to be relatively long-lived, the stocking programs should be viewed as long-term ventures. Loombah Weir was one the first waters stocked in the Victorian trout cod stocking program and it took nearly 10 years to observe some success. Monitoring of several other trout cod stocking sites nation-wide has also returned evidence of initial survival and growth of the stocked fish (Douglas et al. 1994) so it is likely that other sites may also show evidence of breeding and recruitment in the next few years.

Spawning and recruitment to three years of age is a positive step towards the aim of creating viable wild trout cod populations from releases of captive-bred, fish. Future monitoring in Loombah Weir should follow the progress of the naturally spawned generation towards this goal.

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